Telecommunications and Information Technology Planning

The telecommunications and information technology planning function represents the highest-level system or network perspective of the Institute. This work can be characterized generally as planning and analyzing existing, new, and proposed telecommunications and information technology systems, especially networks, for the purpose of improving efficiency and enhancing the technical performance and reliability of those systems. In many cases, ITS performs this work for both wireline and wireless applications. This portion of the ITS technical program encompasses work that is frequently referred to in industry as "systems engineering."

All phases of strategic and tactical planning are conducted under this work area, as well as problem solving and actual implementation engineering. ITS engineers identify users' functional requirements and translate them into technical specifications. Telecommunication system designs, network services, and access technologies are analyzed, as well as information technologies (including Internet and Internet-related schemes).

Following is a summary of significant activities that occurred in the area of telecommunications and information technology planning during FY 2006. Telecommunications interoperability remains the largest program area.

Areas of Emphasis

Interoperability Efforts for Justice/Public Safety/Homeland Security
The Institute conducts a broad-based technical program aimed at facilitating telecommunications interoperability and information-sharing among dissimilar wireless and information technology systems within the justice/public safety/homeland security community. ITS activities are sponsored by several Federal Agencies and programs, and are planned and performed after close coordination with local, State, tribal, and Federal practitioners. Technical thrusts within the program, described in separate sections on the following pages, include:

Statement of Requirements for Public Safety Communications

Public Safety Architecture Framework (described on pp. 38-39)

Standards Development for Public Safety Interoperability

Project 25 Compliance Assessment Program

Department of Commerce ISSI Emulation and Test System (DIETS)

Emergency Telecommunications Service (ETS) Standards Development
The Institute develops and verifies ETS Recommendations for ITU-T Study Group 9. The project is funded by the National Communications System.

Multimedia Quality Research
The Institute characterizes and analyzes the fundamental aspects of multimedia quality assessment and network interoperability. A primary goal of this research is to develop an algorithmic system to objectively assess multimedia quality by combining audio quality, video quality, and audiovisual synchronization information. The project is funded by NTIA.

Wireless Network Measurement Methods
The Institute studies the performance characteristics of wireless networks and attempts to standardize measurement methods in order to better understand the applicability of different types of wireless networks to specific user requirements. The project is funded by NTIA.

Statement of Requirements for Public Safety Communications

Outputs

- Statement of Requirements for public safety communications interoperability, Volume I, version 1.1.
- Statement of Requirements, Volume II.
- Voice and video quality testing.
- Technical management of practitioner working group to review and revise the Statement of Requirements.

The Department of Homeland Security's (DHS) Public Safety Wireless Communications (SAFECOM) Program released the first ever Statement of Requirements for public safety communications interoperability (PS SoR) in April 2004. This statement defined future requirements for crucial voice and data communications in day-to-day, task force, and mutual aid operations. The National Institute of Justice's CommTech Program (formerly AGILE) partnered with SAFECOM in formulating and releasing the requirements.

ITS manages the PS SoR program for the DHS Office of Interoperability and Compatibility (OIC). In this capacity, ITS leads the day to day development of the document, including the written revisions and the laboratory work used in developing the qualitative and quantitative requirements, and provides the long term strategy and vision for the document's maturation and use.

In April 2006, SAFECOM released an updated version of Volume I of the Statement of Requirements (PS SoR, Volume I, version 1.1) with refinements based on input from the emergency response community. In October 2006, SAFECOM released Volume II of the Statement of Requirements.

With the Statement of Requirements, the Nation's 60,000 emergency response agencies — for the first time — have a document that serves as a first step toward establishing base-level communications and interoperability standards for all emergency response agencies. The Statement of Requirements helps the emergency response community convey a shared vision that ultimately will help private industry better align research and development efforts with critical interoperable communication needs.

Version 1.1 (Volume I) of the PS SoR is intended to encourage and facilitate communications industry efforts to align research and development with emergency responder needs. It includes a description

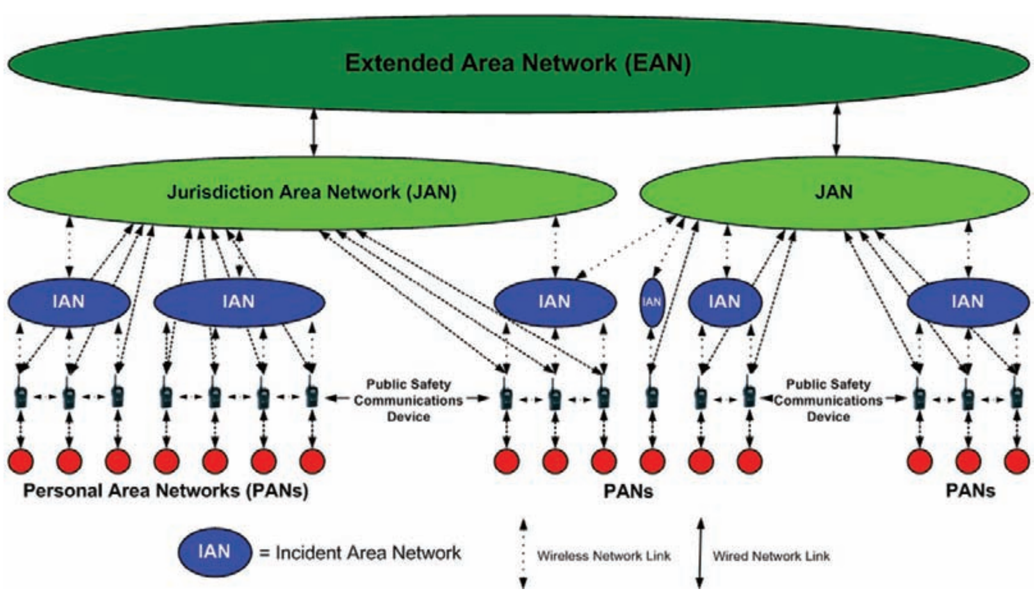

Figure 1. Logical system of systems diagram.

Figure 2. ITS staff members perform practice testing for the video quality testing described on pp. 36-37 (photograph by C. Ford).

of the "system of systems" (shown in Figure 1) concept that is central to OIC's efforts to advance emergency communications interoperability. This approach, which is based on interface standards, gives emergency response agencies the flexibility to select equipment that best meets their unique technical requirements and budget constraints, and allows systems owned and operated by different emergency response agencies to communicate without having to purchase equipment from the same manufacturer.

PS SoR Volume II, Version 1.0, covers three main areas: speech, video, and network performance. The initial application of this document is for mission-critical speech and video services, in addition to specifying network performance parameters to meet these applications' quality of service needs. ITS conducted the voice and video testing, and partnered with the National Institute of Standards and Technology (NIST)'s Advanced Networking Technology Division (ANTD) for network performance, involved in the creation of this document. See the Public Safety Video Quality section on pp. 36-37 for more information.

To help review and revise the PS SoR, the OIC established a working group comprised of members of the emergency response community from all disciplines with specialized expertise, knowledge, and understanding of communications technology. ITS, on behalf of the NIST Office of Law Enforcement Standards, acts as the technical manager for this practitioner working group. This working group will continue to provide on-going feedback and recommendations for future improvements to the document.

The Institute's involvement in the creation and ongoing development of the PS SoR has resulted in the team's reception of a Department of Commerce Gold Medal, which was awarded in November 2006.

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Standards Development for Public Safety Interoperability

Outputs

- Functional and performance specifications for Project 25/TIA digital radio & system standards.
- Standardized measurement methods for testing Project 25 radios and systems.
- Technical contributions to TIA-TR8 and APIC working groups.

Too often, public safety practitioners' communications systems do not meet their needs for operability (security, service area, performance, and survivability for intra-agency communications) and interoperability (inter-discipline and inter-jurisdiction communications where and when communications are needed). ITS, in cooperation with other agencies, is committed to addressing these operability and interoperability problems. A key step in achieving interoperability for public safety communications equipment is the standardization of the technical interfaces, protocols, measurement methods, and performance requirements for public safety communications equipment.

Standards development activities for the public safety community's new generation digital land mobile radio systems are being performed under a joint effort of public safety users and equipment manufacturers. The users are represented by local, State, and Federal government organizations and manufacturers are represented by industry members of the Telecommunications Industry Association (TIA). This standards development process is known as Project 25 (P25). P25 members establish user requirements and draft specifications based on the users' perspective, and TIA (and its TR-8 Committee) uses processes accredited by the American National Standards Institute (ANSI) to develop formal, nationally recognized standards that can be used to design and manufacture equipment and evaluate its performance and interoperability. ITS represents users on technical contributions and issues and provides guidance when technical decisions are to be made. ITS holds leadership positions within several P25 Working Groups: Vice Chair of the Inter-Radio Frequency Subsystem Interface (ISSI) Task Group, Vice Chair of the P25 Systems Architecture Working Group (PSAWG), Vice Chair of the Vocoder Task Group (VTG), and Chairman of the BroadBand Task Group (BBTG).

With Congress providing grants to state and local governments for telecom equipment and the funding for Federal public safety communications systems, Congressional bills have defined the importance of having P25 standards in place. As a result, the P25 Steering Committee and technical committees have set aggressive timeframes for completion of the documents that make up the standards associated with each P25 interface.

On behalf of the public safety community, ITS facilitated development of P25/TIA Standards for radio system interfaces critically needed by users. Through direct and extensive intervention with government and industry representatives and technical contributions across many fronts, ITS was responsible for advancing progress in the P25 Steering Committee and P25 and TIA TR-8 technical committees and associated APIC working groups more during the last two fiscal years than the previous 10 years combined. In FY 2006, critical specifications were standardized by TIA and ITS was instrumental in their completion. Most notably, the ISSI Messages and Procedures Standard (TIA-102.BACA-A) was finished and approved. The U.S. Congress deems ISSI to be the most critical interface for public safety interoperability. The Messages and Procedures Standard is the protocol for this interface and hence the most important standard of the ISSI suite. ITS is also a major contributor in these key P25 areas:

- ISSI Measurement Methods: TIA-102.CACA
- ISSI Performance Recommendations: TIA-102.CACB
- P25 Statement of Requirements
- ISSI Methods and Procedures Errata: TIA-102.BACA-1

Figure 1 identifies the principal functional entities involved in providing and using P25 voice services involving the ISSI. These functional entities are the Radio Frequency Subsystems (RFSSs), the ISSI, Subscriber Units (SUs), and Network Equipment

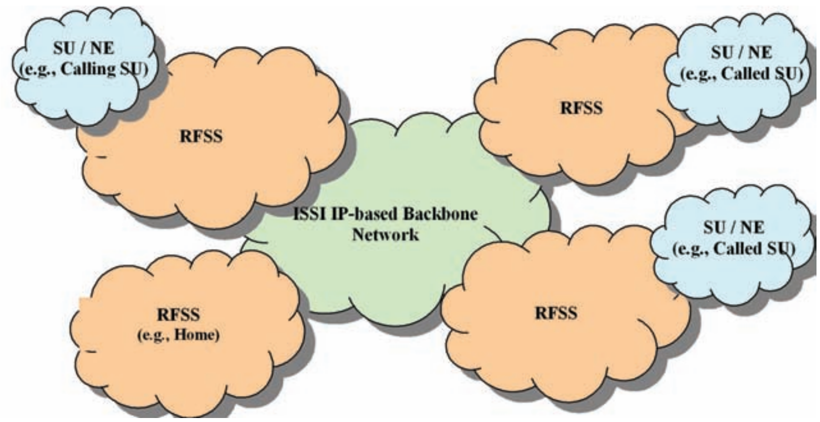

Figure 1. Principal functional entities supporting P25 wide area voice services involving the ISSI.

(NE). Multiple SUs and supporting NE are interconnected via RFSSs to enable P25-standardized wide area voice services. The ISSI IP-based backbone network, a "network of networks," establishes connectivity among RFSSs that implement ISSI functional services and protocols.

In addition to ISSI-related standardization, important work in public safety communications security is ongoing in P25 and TIA TR-8 as well. Currently the key areas in security where ITS is making significant contributions include the P25 Security Services Architecture Overview, the P25 Digital Land Mobile Radio Link Layer Encryption, the Key Management Facility (KMF) Interface Standard, security requirements and profiles for the ISSI, and an update of the Over The Air Rekeying (OTAR) specification.

Figure 2 is one view of how the rekeying of a land mobile radio might be accomplished as the radio roams from one KMF's domain to another (or from its home system to a visited system). The sequential steps in this proposed method are shown in the figure. In this method the visited KMF contacts the radio's home KMF to obtain key management information necessary to rekey the radio for operation in the visited system. Key management messages (KMMs) contain the new key information that are used in OTAR.

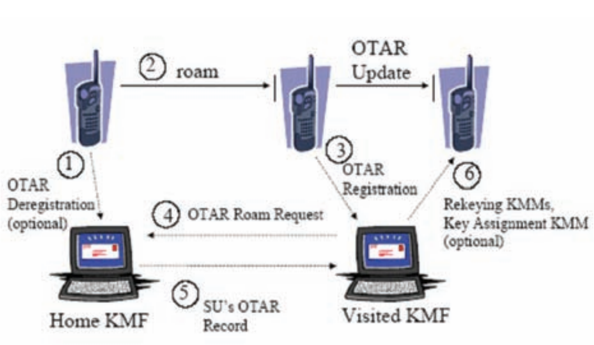

Figure 2. Inter-KMF roaming for end-to-end key management.

ITS is working on standardization in other standards development organizations (SDOs) as well. In Project MESA, a joint effort of the European Telecommunications Standards Institute (ETSI) and TIA, efforts have concentrated on defining the public safety requirements for broadband mobile applications worldwide. ITS has provided user operational requirements that represent the views of U.S. public safety users. An ITS engineer is Chair of the Technical Specification Group — Systems. In the Institute of Electrical and Electronics Engineers, (IEEE), ITS engineers are investigating 802.11x and 802.16x to determine their suitability for Public Safety telecommunications applications.

The ITS standards development for public safety program is sponsored by several Federal departments and programs with a keen interest in public safety interoperability, including: National Institute of Standards and Technology Office of Law Enforcement Standards, Department of Justice Office of Community Oriented Policing Services, Department of Homeland Security's Public Safety Wireless Communications (SAFECOM) Program, Federal Partnership for Interoperable Communications, and the Department of Homeland Security Chief Information Officer's Wireless Management Office. This work is being done in conjunction with projects underway in multiple public safety organizations and is closely tied to other ITS public safety projects.

In FY 2007, ITS will continue to work on the development of technical standards to extend and enhance operability and interoperability in public safety telecommunications.

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Project 25 Compliance Assessment Program

Outputs

- Support of the TIA Project 25 Compliance Assessment Working Group.
- Processes and procedures document describing approval and operation of Project 25 compliance assessment laboratories.
- Grant guidance language for Federal Project 25 equipment grant programs which defines Project 25 compliance requirements.

In FY 2006, ITS engineers continued to play key roles in support of the National Institute of Standards and Technology's (NIST) Office of Law Enforcement Standards (OLES) efforts to implement a compliance assessment program for Project 25 land mobile radio equipment. The program was initiated in response to Congressional legislation which mandated that "when Project 25 equipment is purchased with [grant] funds, the equipment meets the requirements of a conformity assessment program"[1] and that the grantors should at a minimum "require that all grant dollars for interoperable communication be used for Project 25 compliant equipment that meet the requirements of a conformity assessment program."[2] Work on the program began in earnest in April 2005 following a request from the Project 25 Steering Committee.

The Project 25 standard is being rolled out in phases and the compliance program is being structured to follow suit. Originally begun in 1989, Project 25 will ultimately define eight open interfaces:

1. Common Air Interface
2. Inter-RF Subsystem Interface
3. Fixed Station Subsystem Interface
4. Console Subsystem Interface
5. Network Management Interface
6. Data Network Interface
7. Subscriber Data Peripheral Interface
8. Telephone Interconnect Interface

To date, only the Common Air Interface (CAI) has been sufficiently developed to allow for development and deployment of interchangeable equipment. Accordingly, compliance assessment will begin with the CAI. As the program matures, testing will encompass the essential elements of compliance as defined by the Telecommunications Industry Association (TIA) Mobile and Personal Private Radio Standards (TR-8) subcommittee. They include the following types of tests:

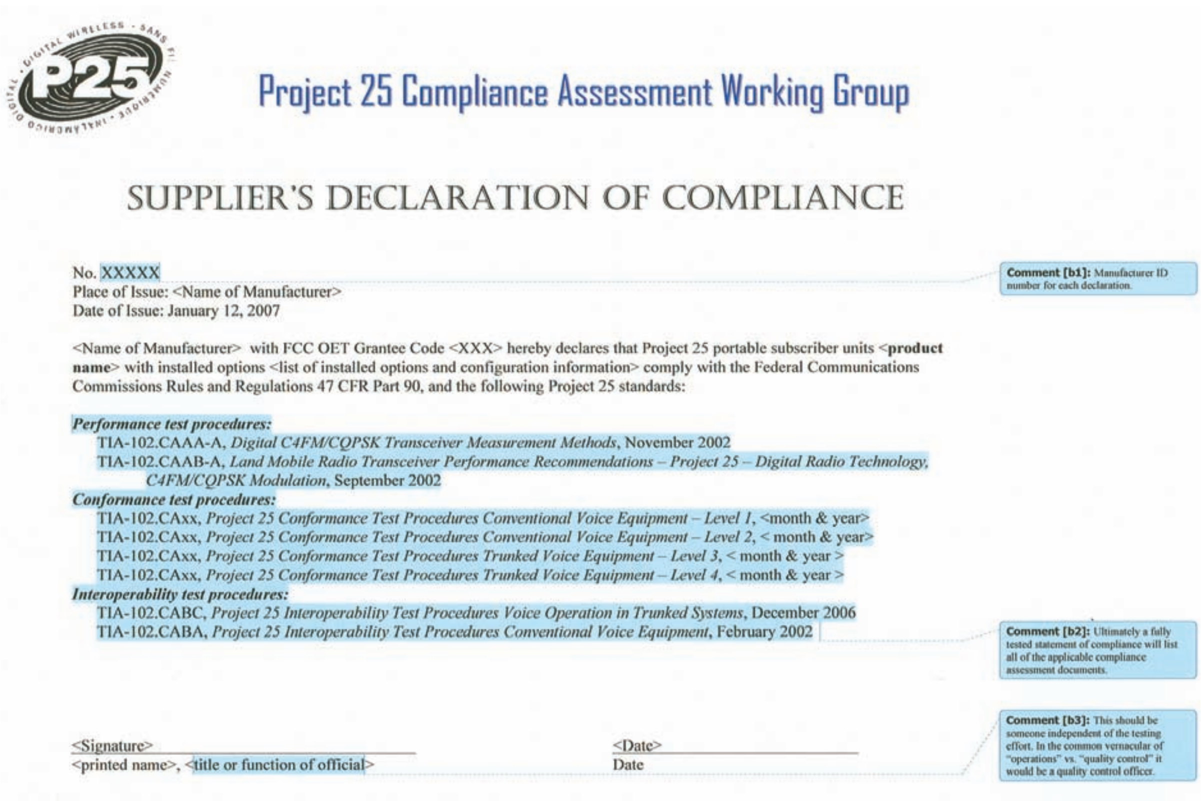
- Performance: measurements that verify the specifications for a component or sub-system.
- Conformance: bit-by-bit, message-by-message protocol verification.
- Interoperability: functional "can-you-hear-me-now" type testing to validate equipment interchangeability.

A framework for the program was developed by government and industry officials in 2006. Initially a third-party laboratory accreditation program was envisioned by representatives from ITS and NIST; however, industry members argued that third-party participation would hinder the program, as the unique nature of the Project 25 protocols and the subsequently steep learning curve would tax both third-party labs and Project 25 manufacturers alike. As an alternative, Project 25 manufacturers unanimously volunteered the use of their internal laboratories and facilities as test beds. They also agreed to submit to peer assessments of their laboratories' competence. Such an approach is formally known as a first-party, peer assessment model.

Peer assessment involves both initial laboratory assessments for competence and quality control processes as well as laboratory audits or reviews where processes and documentation are assessed. The policies and procedures for the program will be captured in a NIST publication to be entitled *Procedures and General Requirements for Compliance Assessment of Project 25 Land Mobile Radio Equipment*.

1 House Report 109-241 - "Making Appropriations for the Department of Homeland Security for the Fiscal Year Ending September 30, 2006, and for Other Purposes."

2 Senate Report 109-088 - "Department of Commerce and Justice, Science, and Related Agencies Appropriations Bill, 2006."



SUPPLIER'S DECLARATION OF COMPLIANCE

No. XXXXX
Place of Issue: <Name of Manufacturer>
Date of Issue: January 12, 2007

<Name of Manufacturer> with FCC OET Grantee Code <XXX> hereby declares that Project 25 portable subscriber units <**product name**> with installed options <list of installed options and configuration information> comply with the Federal Communications Commissions Rules and Regulations 47 CFR Part 90, and the following Project 25 standards:

Performance test procedures:
TIA-102.CAAA-A, *Digital C4FM/CQPSK Transceiver Measurement Methods*, November 2002
TIA-102.CAAB-A, *Land Mobile Radio Transceiver Performance Recommendations – Project 25 – Digital Radio Technology, C4FM/CQPSK Modulation*, September 2002
Conformance test procedures:
TIA-102.CAxx, *Project 25 Conformance Test Procedures Conventional Voice Equipment – Level 1*, <month & year>
TIA-102.CAxx, *Project 25 Conformance Test Procedures Conventional Voice Equipment – Level 2*, < month & year>
TIA-102.CAxx, *Project 25 Conformance Test Procedures Trunked Voice Equipment – Level 3*, < month & year >
TIA-102.CAxx, *Project 25 Conformance Test Procedures Trunked Voice Equipment – Level 4*, < month & year >
Interoperability test procedures:
TIA-102.CABC, *Project 25 Interoperability Test Procedures Voice Operation in Trunked Systems*, December 2006
TIA-102.CABA, *Project 25 Interoperability Test Procedures Conventional Voice Equipment*, February 2002

<Signature> <Date>
<printed name>, <title or function of official> Date

Comment [b1]: Manufacturer ID number for each declaration.

Comment [b2]: Ultimately a fully tested statement of compliance will list all of the applicable compliance assessment documents.

Comment [b3]: This should be someone independent of the testing effort. In the common vernacular of "operations" vs. "quality control" it would be a quality control officer.

Sample ISO 17050-1 compliant supplier's Declaration of Compliance.

Manufacturers will conduct tests in accordance with normative standards adopted by the Project 25 Steering Committee, which are typically published by TIA. In this area as well, ITS is making a significant contribution to facilitate the accelerated completion of the test standards. For example, ITS engineers are editing the Project 25 Standard, *Interoperability Testing for Voice Operation in Trunked Systems*, which will be published as TIA-102.CABC-A.

Program participants will produce and keep detailed test results for each device or system. For the Project 25 consumer they will produce at-a-glance type summary test reports using standard formats to simplify interpretation of the results and, where applicable, product comparisons. A product that has been tested against all of the available, published, normative test standards is deemed to be compliant — not by an independent third party, but by the manufacturer itself. Such a declaration or self-certification is made by a responsible company official following guidelines established in ISO/IEC 17050-1. Each Supplier's Declaration of Compliance (SDoC) details a product's configuration and the types of tests conducted on it. The documented test reports and the subsequent company declaration should go a long way toward increasing the public safety community's confidence in Project 25 equipment.

The Project 25 Compliance Assessment Program is voluntary in nature; participating Project 25 manufacturers need not test their products nor declare compliance. However, as the law mandates, public safety agencies seeking to use grant funds to purchase Project 25 equipment must select from compliant equipment with an accompanying SDoC.

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Department of Commerce ISSI Emulation and Test System (DIETS)

Outputs

- An ISSI reference implementation.
- Software capable of conformance testing the ISSI protocol.

The importance of the Project 25 (P25) suite of standards has been conveyed by Congress through several pieces of recent legislation. With Congress providing grants to all levels of government (local, State, and Federal) for the acquisition of public safety telecommunications equipment, the suite of P25 standards is necessary to ensure interoperability among the different levels of government. Congress considers the Inter-RF Sub-System Interface (ISSI), one of seven P25 interfaces, to have top priority for completion.

ISSI can be thought of as a network protocol that is able to utilize a standard network interface card (NIC). The intent is for this interface to be present in future deployments of P25 Radio Frequency Sub-Systems (RFSS). A P25 RFSS is the infrastructure equipment that enables land mobile radios to communicate with each other and to dispatchers within a P25 system. An RFSS provides open P25 interfaces that enable narrowband voice and data services, including communication among radio users located in disparate coverage areas supported by different RFSSs. The ISSI of different RFSSs can be interconnected using various mediums, but the most common is Ethernet. When the ISSIs of various RFSSs are interconnected, IP packets that contain encoded voice can be transmitted and received. The ISSI is important to public safety agencies because it will foster competition among several vendors who manufacture RFSSs. Over time, this increased competition should drive down the cost of P25 infrastructure. In addition to lower cost, the most important reason for having an ISSI interface is to promote interoperability between the different vendors who manufacture RFSSs. This allows the end consumer to implement a P25 communications network that consists of RFSSs from multiple vendors.

Testing of the ISSI Interface

A balloted scope one version of the P25 ISSI Messages and Procedures for Voice Services (TIA-102.BACA) specification was formally released in August 2006. Conformance tests are currently being developed and scheduled for completion in early 2007. These conformance tests will verify that the vendor implementation under test conforms at a message level to what has been specified in TIA-102.BACA.

In order to verify objectively that a vendor conforms to TIA-102.BACA, a reference implementation of the ISSI protocol stack has been developed. This software reference implementation is referred to as the Department of Commerce ISSI Emulation and Test System (DIETS). ITS developed this software in conjunction with the National Institute of Standards and Technology's (NIST) Advanced Network Technologies Division. Since DIETS was implemented in Java, the software can be loaded on a regular desktop PC with a Linux or Windows operating system. DIETS is capable of emulating one of four different roles in a P25 ISSI-based network. The roles are (1) calling serving RFSS, (2) calling home RFSS, (3) called home RFSS, and (4) called serving RFSS. The idea is that DIETS will be placed in a test configuration, as defined in the conformance test document, which will fulfill one of the four roles depending on the test case under consideration. An example of this concept is shown in Figure 1. The number of vendor RFSSs and roles may vary depending on the test case requirements.

It is also possible to test in isolation the ISSI of a single vendor RFSS. This scenario implies that there is only one vendor RFSS with a real ISSI and the rest of the ISSI interfaces are emulated by DIETS. An example of this test architecture is illustrated in Figure 2. The number of emulated ISSIs and the role of the emulated interfaces will vary depending on the conformance test case under consideration.

Since DIETS does not currently have the capability to emulate the P25 common air interface, the behaviors of (or events generated by) subscriber units are emulated in the DIETS software. The conformance tests are implemented in XML scripts. The user has the capability to modify the specific test parameters in these scripts as necessary. As an example, the number of subscriber units involved in the conformance test is a parameter that the user can modify.

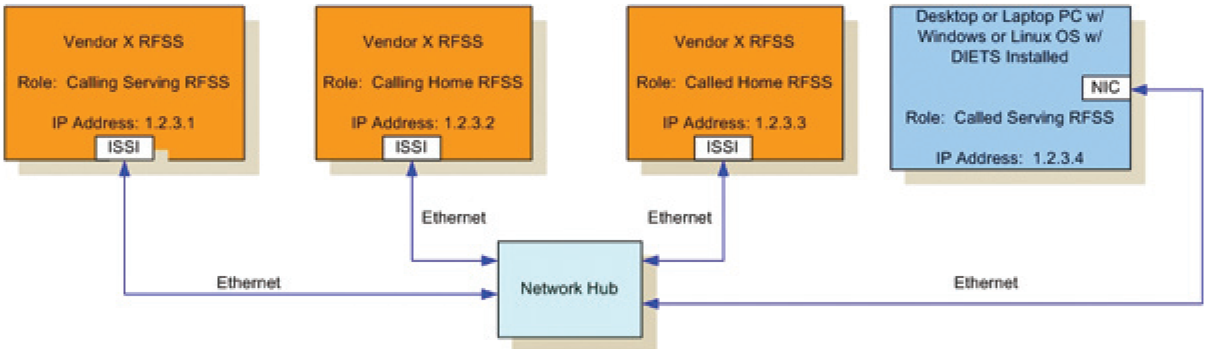

Figure 1. Test architecture with only one instance of DIETS. In this particular scenario, the network hub is critical to enabling packet collection from all Ethernet links. (IP addresses are for example purposes only, and these particular addresses are not meant to be used in a real network configuration.)

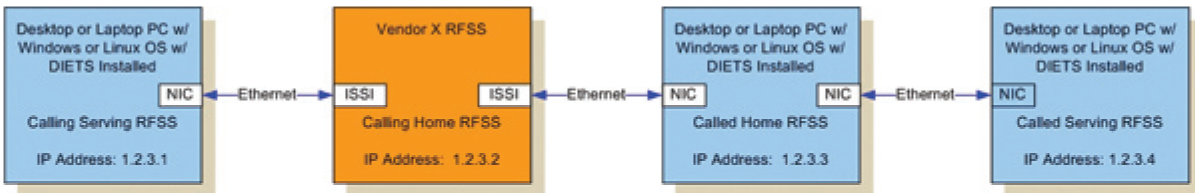

Figure 2. Test architecture with three instances of DIETS (IP addresses are for example purposes only).

From the DIETS graphical user interface (GUI), the user selects a conformance test case to execute. After the test case has completed execution, the user can then view the session initiation protocol (SIP) and real-time transport protocol (RTP) Push-to-Talk (PTT) messages that were exchanged between ISSIs in a graphical message sequence chart (MSC) to determine if the test case passed or failed. Raw IP packet data can be rendered by clicking on the message of interest in the MSC. DIETS has a packet capture ability that is based on the Ethereal packet capture (PCAP) engine. This gives DIETS the capability to capture the messaging that occurs between all ISSIs (emulated or real) that are involved in a given test.

Future Direction of DIETS

In addition to the ISSI, there are two other wireline interfaces that DIETS can be expanded to test. These interfaces are the Fixed Station Interface (FSI) and the P25 Trunked Console Interface (CI). The FSI standard, TIA-102.BAHA, was formally published in 2006. The CI is scheduled to be balloted in January 2007, and the intent is that this standard will be an addendum to TIA-102.BACA.

The primary purpose of the FSI is to enable connectivity of a fixed station (i.e., base station) to an RFSS. The FSI can be thought of as a protocol stack. The intent of this interface is to allow interoperability between different vendors' fixed stations and RFSSs. The physical medium that will interconnect FSIs is not limited to Ethernet.

The primary purpose of a trunked console interface is to enable the connectivity of a dispatcher's console to an RFSS's CI. The CI is very similar to the ISSI with minor variations.

The conformance document for the FSI is nearly complete and will be balloted in January 2007. As for the CI, the conformance test cases will be added to the ISSI conformance document. DIETS can be expanded to enable objective message level conformance testing of the FSI and CI. In addition to expanding DIETS's capability to test additional P25 interfaces, DIETS also can be expanded to test the performance of the ISSI according to the Project 25 ISSI Measurement Methods for Voice Services standard. At this time, the direction in which DIETS will be expanded is under consideration.

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Emergency Telecommunications Service (ETS) Standards Development

Outputs

- Technical contributions to ATIS Technical Committee PRQC.
- Technical contributions to ITU-T Study Group 9.

In the aftermath of the 2001 terrorist attacks, the Federal Government has become very interested in priority treatment for emergency communications. While the Government Emergency Telecommunications Service (GETS) has served emergency workers well for many years, it is limited to the Public Switched Telephone Network (PSTN) in the United States. The Emergency Telecommunications Service (ETS) is envisioned as a GETS-like service that will be available internationally and encompass virtually all wireless and wireline communications networks. Types of traffic to be carried include voice, video, database access, text messaging, e-mail, FTP, and web-based services.

The ETS Standards Development project conducts laboratory studies, computer simulations, and security analyses to further standards development supporting Critical Infrastructure Protection (CIP) initiatives. This project is funded by the National Communications System (NCS). The work supports NCS in its mission to protect the national security telecommunications infrastructure, and to ensure the responsiveness and availability of essential telecommunications during a crisis.

The ETS Standards Development project provides contributions to two standards development organizations: the International Telecommunication Union's Telecommunication Standardization Sector (ITU-T) Study Group (SG) 9 and American National Standards Institute (ANSI)-accredited Performance, Reliability, and Quality of Service Committee, PRQC. ITU-T SG 9 is the Lead Study Group on integrated broadband cable and television networks, and PRQC works in the areas of Quality of Service (QoS), Reliability, and User-Plane Security.

In SG 9, ITS develops and verifies Recommendations to support preferential telecommunications services and user authentication. The major goal of this project is to ensure that future ETS mechanisms and the current GETS service will interoperate over broadband cable television networks in their delivery of voice, data, and multimedia communications.

In PRQC, ITS provides ETS expertise relating to priority support and network security. During FY 2006, an ITS engineer served as co-editor of several ANSI and Alliance for Telecommunications Industry Solutions (ATIS) Standards and Technical Reports. These provide guidelines, specifications, and requirements for aspects of ETS communications. An ITS engineer serves as the Chair of PRQC's Security Task Force where he leads security standardization for the Network User Plane. He also chairs the ATIS Joint Ad-Hoc Technical Committee for Issues PRQC A0029 and TMOC 95, which works across all relevant ATIS committees to provide a common security baseline suite of standards for telecommunications security in current and Next Generation Networks (NGN).

The standardization work in ITU-T SG 9 is focused on the IPCablecom and IPCablecom2 families of Recommendations. These Recommendations define the protocols and signaling to be used on broadband cable television networks to support telephony, multimedia, and Internet access. The IPCablecom Recommendations have been standardized in ITU-T SG 9, and equipment implementing them is currently in production worldwide. IPCablecom2 has recently been approved and equipment will be deployed in the coming years. One goal of this project is to identify where additions or changes might be needed to support the ETS. This effort also involves work with the Internet Engineering Task Force (IETF), since many of the underlying protocols used in IPCablecom (as well as some of the ETS mechanisms) are under development in the IETF. An ITS engineer served as editor and principal author of ITU-T Recommendation J.260, "Requirements for preferential telecommunications over IPCablecom networks," in SG 9. An ITS engineer also serves as the editor of Draft new ITU-T Recommendation J.pref, "Specifications for preferential telecommunications over IPCablecom networks," and J.preffr, "Framework for implementing preferential telecommunications in IPCablecom networks." J.pref will provide specifications to satisfy the requirements set forth in J.260, and J.preffr will provide a longer-term framework for standardizing preferential services and emergency user authentication in cable networks.

Another important study underway at ITS is a series of tests of GETS over IPCablecom networks. The evolution of GETS from a PSTN-only service to one that will interoperate over the wireless, IPCablecom, and Next Generation networks is an NCS goal. Another goal of this effort is determining the security needs of ETS in IPCablecom networks.

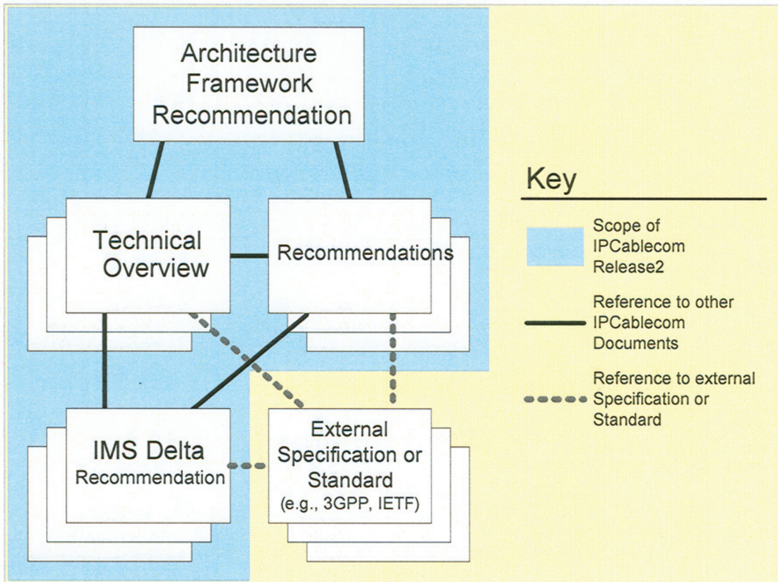

Figure 1. IPCablecom2 organization.

The diagram in Figure 1 shows the organization of IPCablecom specifications. IPCablecom2 is the next generation of IPCablecom and is based on the 3rd Generation Partnership Project's (3GPP) IP Multimedia Subsystem (IMS) architecture. The diagram shows the relationships between the various standards that make up IPCablecom2. The goal is to develop standards that support both GETS and ETS in IPCablecom2 as well as earlier versions of IPCablecom.

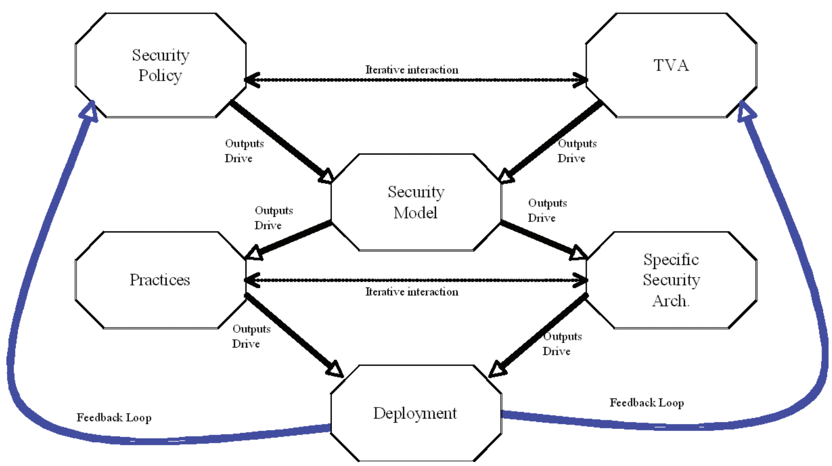

Figure 2. Security engineering major activity areas.

Figure 2 shows the major activity areas for security engineering of telecommunications networks. Threat Vulnerability Analysis (TVA) and Security Policy combine to form a Security Model which then drives Practices, Architecture, and Deployment. This diagram is from the draft Technical Report underway in the ATIS Joint Ad-Hoc Technical Committee for Issues PRQC A0029 and TMOC 95. Joint effort with the other ATIS groups doing security work is vital and will allow us to better define and coordinate this important network security work.

In FY 2007, ITS will continue to work on the development and standardization of ETS in ATIS PRQC, the IETF, and ITU-T SG 9. The projects will address technologies in the NGN and interactions with the IPCablecom networks. This work on ETS must of necessity be conducted with the help of representatives from network providers and cable television equipment manufacturers, as well as NCS. The work in FY 2007 will focus on priority and security in the NGN ETS as well as GETS and ETS compatibility in the IPCablecom and IPCablecom2 networks.

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Multimedia Quality Research

Outputs

- Technical contributions to VQEG.
- Technical contributions to ITU-T Study Group 9.

The transmission of audio/video (multimedia) signals over wireline and wireless channels has increased exponentially in the past decade. In particular, the distribution of multimedia signals over wireless links to devices such as laptops, personal digital assistants (PDAs), and cellphones is widespread and the need for quality measurements is great. The widespread use of digital technology for the transmission of audio and video signals has led to the need for new objective quality assessment methods based on human perception. ITS has a long history of successful research in the areas of voice and video quality assessment. Until recently, however, the development of an objective measure of overall multimedia quality has not been adequately addressed.

Multimedia is defined here as the combination of audio and video in the communication of information. The objective of the ITS Multimedia Quality Research project is to characterize and analyze the fundamental aspects of multimedia quality assessment. A primary goal of this research is to develop an algorithmic system to objectively assess multimedia quality by combining audio quality, video quality, and audiovisual synchronization information.

In 2003, International Telecommunication Union — Telecommunication Standardization Sector (ITU-T) Recommendation J.148 was approved by Study Group 9, entitled "Requirements for an objective perceptual multimedia quality model." ITS staff contributed significantly to this Standard. Figure 1 is a diagram from J.148 showing the basic components of a multimedia quality assessment system. The boxes marked "Audio Quality" and "Video Quality" represent subsystems that assess the audio and video quality. The box marked "Differential Delay" outputs a measure of the error in synchronization between the audio and video channels in the audiovisual signal.

The box marked "Multimedia quality integration function" is the subsystem that will combine the previous subsystems' outputs to predict the overall multimedia quality. It will apply specific rules to the information provided by the other subsystems. The form of these rules will be based on data derived from subjective quality experiments. The aim is to produce a set of integration rules that enable the multimedia model to accurately predict human quality perception of systems and services under test. Therefore the validity of the model must be shown

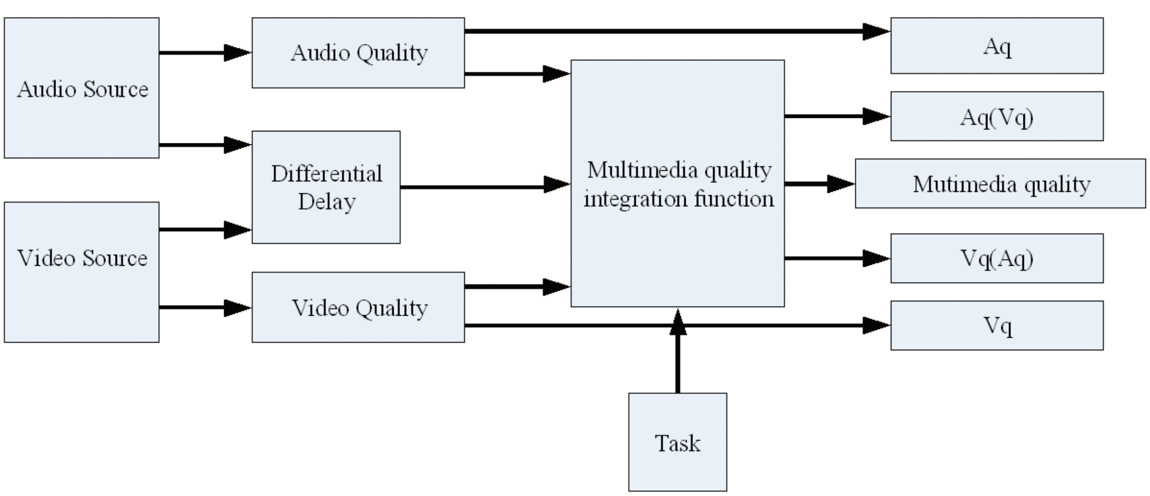

Figure 1. Basic components of a multimedia model.

by comparing the performance of the model against quality ratings obtained from subjective tests for a range of test materials.

The complete multimedia model provides five outputs. The primary output is a predicted measure of overall multimedia quality. Four subsidiary outputs provide predictions of perceived quality for the audio (denoted Aq), video (denoted Vq), audio accounting for any influence the video may have (denoted Aq(Vq)), and video accounting for any influence the audio may have (denoted Vq(Aq)).

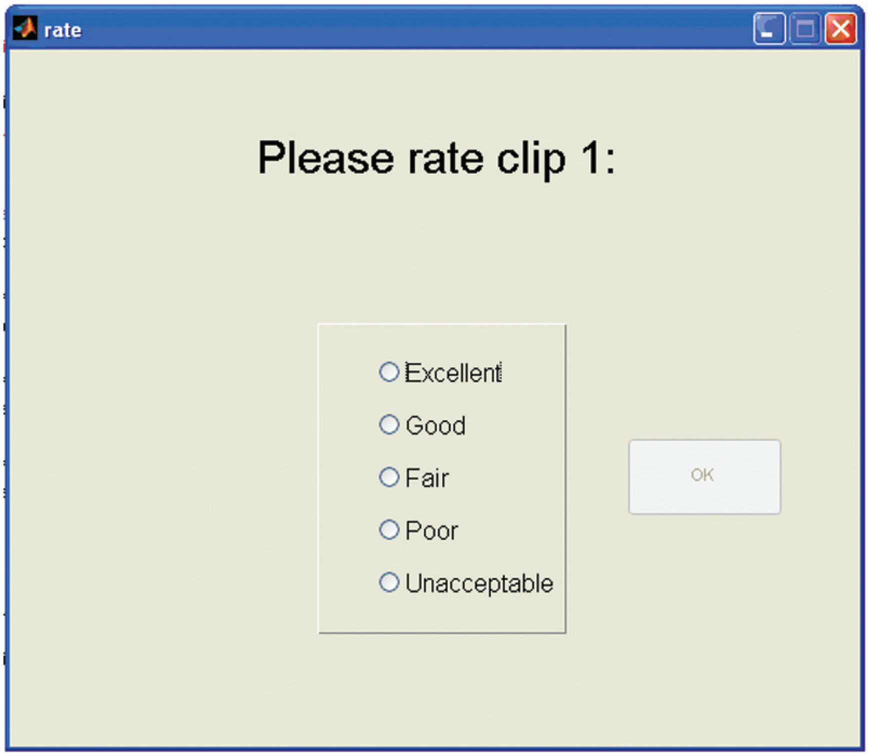

Figure 2. Subjective test scoring dialog box

Subjective testing has played an important part in ITS efforts to develop voice and video quality assessment methods. For multimedia research, subjective testing is no less important. Objective quality assessments are based on data derived from subjective quality experiments. A series of multimedia subjective tests will be executed to explore the relationships between the quality parameters for audio, video, and audiovisual synchronization. This will provide data for the development of the integration function.

Subjective testing employs human subjects to rate multimedia quality. The results are used to train and test the objective measurements calculated by the models. ITU Recommendations provide standardized methodologies for subjective testing of voice, audio, video, and multimedia. One of the methods used by ITS is the Absolute Category Rating (ACR) method. Figure 2 shows a multimedia clip rating box utilizing the ACR method. The testing system will play a multimedia clip on a computer screen and speakers and then display the rating box to elicit the subject’s judgment of the quality. By averaging the scores of each clip from many subjects, a realistic assessment of the quality is obtained.

This work is being done in conjunction with projects underway in the Video Quality Experts Group (VQEG) and the ITU-T Joint Rapporteur Group on Multimedia Quality Assessment (JRG-MMQA). The JRG-MMQA is an official body of the ITU and is formed from members of ITU-T Study Groups 9 and 12.

In FY 2007, ITS will continue to work on the development of a multimedia quality assessment model by conducting subjective experiments and analyzing the results.

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Wireless Network Measurement Methods

Outputs

- Public safety 4.9-GHz indoor propagation and throughput measurements.
- Asynchronous radiated power measurement techniques for 802.11-based systems.

Federal operations have historically exhibited a heavy dependence on wireless networks, but these have typically been of the land mobile radio variety, with analog modulation methods and simple network topologies. In recent years, a more data-centric view of Federal operations has gained favor, probably fueled by the wide availability of high speed enterprise local area networks and the increased data processing ability of the ubiquitous desktop computer. This philosophy requires the ability to transmit significant volumes of digital data over the telecommunication medium being used, and its effects are being felt in the design of wireless networks.

Modern wireless networks are apt to be heavily weighted toward data transmission, with digital modulation and sophisticated protocol overlays. Since the Internet Protocol (IP) is so well known, it is often the kernel protocol of choice, but it may be encapsulated at the MAC and physical layers by other protocols like 802.11 or 802.16. New topologies, like mesh networking, are also being investigated. Finally, since these technologies often require greater spectral allocations than traditional voice services, spectrum reallocations to reassign spectrum for wireless data networking are becoming more commonplace.

As wireless technologies mature, manufacturers and standards bodies introduce test methods and instrumentation to investigate their behavior. However, at the introduction of a new wireless networking technology, or when a legacy technology is implemented within a new spectral regime, test methods and instrumentation must be developed. The ITS Wireless Network Measurement Methods project is charged with meeting these requirements.

Currently, the system under investigation is an 802.11j wireless data network operating in the licensed 50-MHz spectral band between 4.945 GHz and 4.995 GHz. This band has been assigned to Public Safety organizations and is also the spectral support for the 802.11j networking protocol. ITS engineers have studied this network operating within several different propagation environments, including outdoor to indoor, and indoor professional and residential environments.

The primary metric used in these measurements has been network throughput, as this is the parameter most visible to a public safety user. However, received radiated channel power has also been a parameter of interest, and this portion of the experiment has required the development of some new techniques.

The problem occurs, in 802.11-based systems, because each node is a transmitter as well as a receiver. The switch from one mode to another occurs within a time regime of microseconds, and is essentially asynchronous to the measurement device since no control signal is provided to warn that the node is changing states. A normal power measurement device (such as a swept filter spectrum analyzer) is designed for signals that are considerably less bursty than those provided by 802.11 protocols, so an FFT-based real time analyzer was used with some specialized techniques to prevent hopelessly conflating the transmitted and received signals.

An example of this type of measurement is given in Figure 1 on the next page, where signal strength is plotted on the horizontal axis and percentage of samples is plotted on the vertical axis. The top graph shows a trimodal distribution, where the rightmost peak is the acknowledgement signal transmitted by the network node under investigation, and the central peak shows the level of received channel power. The leftmost peak represents the quiescent noise floor of the test instrument.

These measurements were taken in a hallway where the node under test was continuously receiving 1536-byte packets over a distance of about 50 meters at a throughput rate of 11.5 megabits per second. The measurement represents approximately 250 40-microsecond windows sampled at a rate that gave 1024 points per sample window. The width of the central received peak shows that the radio channel transmission effects and the channel power of

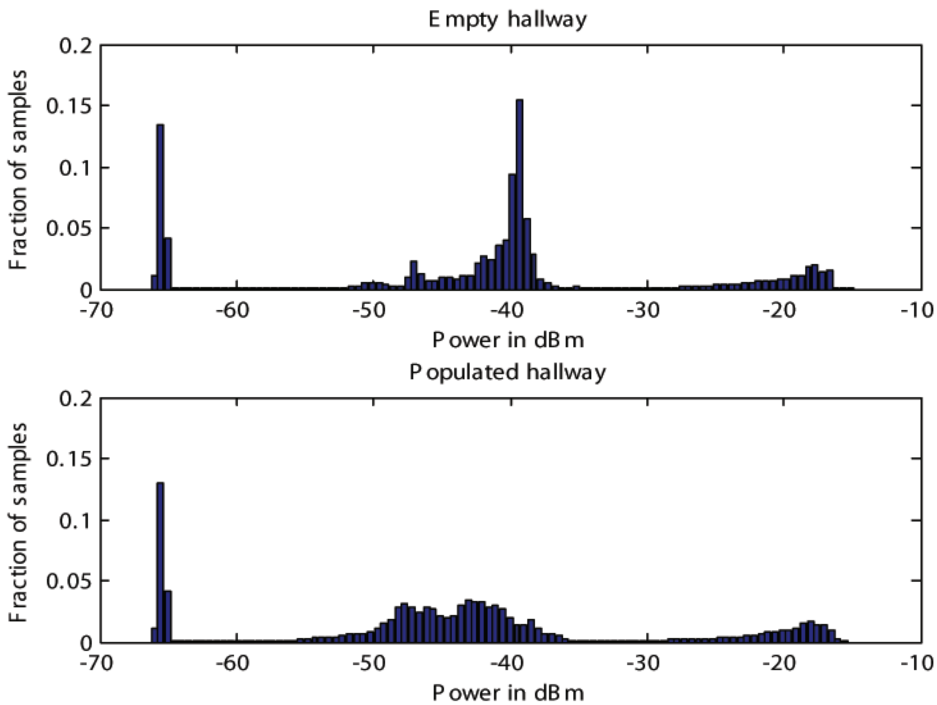

Figure 1. Sampled channel power measurements within an occluded hallway.

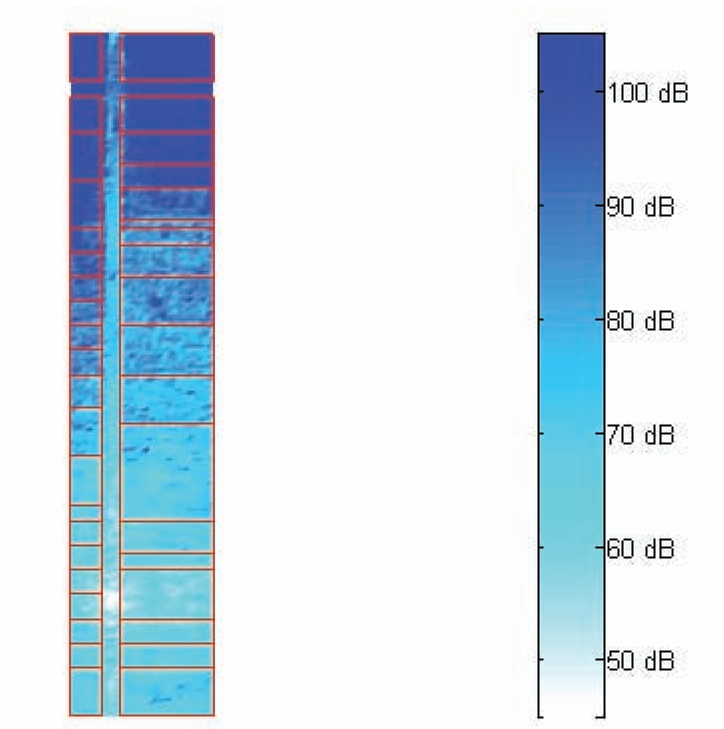

Figure 2. Propagation model path loss predictions for a concrete/concrete block structure. The transmitter is in the light colored area at the lower left, and the red lines represent office walls.

the received signal vary over about a 10-dBm range during a 10-millisecond time regime. A later measurement is shown in the bottom part of the figure, with the hallway RF path occluded by a group of 20 people. Here the received signal has suffered some attenuation, as indicated by the left shift of the central distribution peak.

Measurements like these, coupled with the results of propagation prediction programs like those shown in Figure 2, allow the accurate prediction of coverage areas within complex indoor environments. In addition to providing insights into the benefits and limitations of targeted wireless networking technologies, these tools may be used to ensure coverage for public safety professionals in emergency situations.

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